INTERNATIONAL MARITIME ORGANIZATION

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SUB-COMMITTEE ON SAFETY OF NAVIGATION
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REVISION OF SOLAS CHAPTER V

Carriage Requirements for Radar Reflectors

Note by Comité International Radio Maritime (CIRM)

SUMMARY

Executive summary:	To provide technical information on radar detectability and to propose an amendment to the draft revision SOLAS Chapter V to clarify requirements for radar reflectors.
Action to be taken:	Paragraph 13
Related documents:	NAV 45/5 (annex), resolution MSC.64(67), Annex 4 and resolution A.384(X)

1 In NAV 45/5, annex, the footnote to draft regulation 20.1.2.7 requests Members to consider whether a minimum radar cross section (RCS) of 100 m^2 is an appropriate parameter for radar detectability.

2 Radar manufacturers have been concerned for some time by the detectability of small vessels in poor weather conditions. Rain and higher sea states impose physical limitations on the performance of radars. The results of computer modelling, now used extensively in the industry, give a better understanding of these limitations. As the number of collisions with small vessels continues it is necessary to try and improve their radar detectability, particularly in bad weather.

3 Since the performance standard for radar reflectors (resolution A.384(X)) was introduced in 1977, there have been some significant changes in radar usage:

.1 ship sizes have generally increased, with radar antennae being mounted higher above sea level. This gives increased range, but unfortunately it also gives increased sea clutter;

.2 average speeds have generally increased, with a need for more warning time, i.e.: longer range of detection; and

.3 the use of 3 GHz (S-band) radars is becoming more widespread.

4 The operational requirement for radar in the presence of sea clutter (resolution MSC.64(67), Annex 4, paragraph 3.12.2) is for a clear indication of a standard reflector up to 3.5 nm. Members may therefore consider that a radar reflector should provide detectability by a 9 GHz (X-band) radar at 3.5 nm in bad weather.

5 It would also seem desirable for the same reflector to have good detectability by a 3 GHz (S-band) radar. It should be noted that, since the RCS of a reflector is inversely proportional to the square of the wavelength of the radar, a reflector designed to give 100 m^2 at 9 GHz will give at 10 m^2 response at 3 GHz.

6 At annex 1 is a table derived from computer prediction, comparing an example of radar performance in various weather conditions at 9 GHz against radar reflectors of 10 m^2 and 100 m^2, and at 3 GHz against reflectors of equivalent sizes (1 m^2 and 10 m^2, respectively).

7 This example shows that the maximum 9 GHz detection range of the smaller reflector may be as low as 1.2 nm in rain, and 1 nm in rain and sea state 6. Moreover, even when maximum range is higher, sea clutter produces a dangerous gap in detectability: typically between 1.0 - 2.5 nm. The larger reflector, however, gives an increased range in the worst example of 3.5 nm, with no loss of target within that range.

8 The table also illustrates the superior performance of S-band radar in rain, although in high sea states the smaller reflector (equivalent to only 1 m^2 at that frequency) may not be detectable.

9 A 100 m^2 radar reflector is physically some 80% larger than a 10 m^2 reflector and, at 9 GHz, typically measures some 780 mm across, which seems to be a reasonably practical size for most applications.

10 It is therefore considered that a minimum radar cross section of 100 m^2 at 9 GHz would indeed be an appropriate parameter for radar detectability.

11 However, the radar cross section depends not only on the size and design of the ship, but also on a number of variables, including the ship's aspect and freeboard (depending on loading condition). To measure the minimum radar cross section for each ship (or class) would require swinging the ship whilst fully laden, and could be a comparatively expensive and time-consuming process. Members may therefore feel that it would be more practical to establish a broadly equivalent limit based on size.

12 A typical ship of 150 gross tonnage could, in most cases, be expected to have a minimum radar cross section of 100 m^2 or over. It is therefore suggested that, if a size criterion is preferred, ships of less than 150 gross tonnage should be fitted with a radar reflector or other means to ensure that they are detectable.

Action requested of the Sub-Committee

13 The Sub-Committee is invited:

.1 to take into account the information provided at paragraphs 2 to 12 above, in considering the appropriate parameter for radar detectability; and

.2 to amend the draft revised SOLAS Chapter V as indicated in annex 2, attached.

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ANNEX 1

PERFORMANCE IMPROVEMENT WITH RADAR REFLECTOR SIZE

Sea State 6 (Wind Speed 28-47 knots, North Atlantic)
Rain 16 mm/hour

Antenna Height 30 m. Reflector Height 4 m. Radar horizon 16.6 nm.

Radar Parameters: 9.41 GHz 25k W Peak Power, 1.9 m aerial width
3.05 GHz 30k W Peak Power 3.8 m aerial width.

Range detection criteria: 50% blip/scan ratio.

Target echoing area at 9 GHz of 10 m^2 is effectively one tenth at 3 GHz i.e. 1 m^2

Radar	**9 GHz**		**3 GHz**	
Reflector Size	**10 m^2**	**100 m^2**	**1 m^2**	**10 m^2**

SEA STATE 6

Maximum detection range. nm	7.5	5.0	4.5	8.5
Extent of sea clutter. nm	5.0	5.0	4.0	4.0
Range of target visibility above clutter. nm	0 - 1.0 2.5 - 7.5	0 - 14.0	3.0 - 4.5	0 - 8.5
Range of Target loss due to sea clutter. nm	1.0 - 2.5	Not lost	0 - 3.0	Not lost

RAIN 16 mm/hour

Maximum detection range. nm	1.2	3.5	8	8
Extent of rain clutter. nm	12.0	12.0	8.0	8.0
Range of target visibility above clutter. nm	0 - 1.5	0 - 3.5	0 - 2.5	0 - 8.0
Range of Target loss due to sea clutter. nm	1.2 - 7.5	3.5 - 14.0	2.5 - 4.5	8.0 - 8.5

SEA STATE 6 AND RAIN 16 mm/hour

Maximum detection range. nm	1.0	3.5	Not detected	8.0
Extent of sea clutter. nm	4.0	4.0	4.0	4.0
Extent of rain clutter. nm	12.0	12.0	8.0	8.0
Range of target visibility above clutter. nm	0 - 1.0	0 - 3.5	Not detected	0 - 8.0
Range of Target loss due to sea clutter. nm	1.0 - 7.5	3.5 - 14.0	0 - 4.5	8.0 - 8.5

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ANNEX 2

Proposed amendment to draft revised SOLAS Chapter V (NAV 44/5, annex)

Draft regulation 20.1.2: Amend subparagraph .7 to read:

".7 ~~if the ship's minimum radar cross section is less than [100 m^2]~~ if less* than 150 gross tonnage and if practicable, a radar reflector providing an effective radar cross section of 100 m^2 at 9 GHz and capable of operation at 9 and 3 GHz, or other means to ensure that they are detectable by ships navigating by radar."

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* Underlined text is new proposed text